LAKE STATES FOREST EXPERIMENT STATION

REPORT TO THE ADVISORY COMMITTEE

FOR 1926

Three Years' Progress

September 1, 1926, marked the third anniversary of the establishment of the Lake States Forest Experiment Station. It is of interest to record the progress made during the last three years in the three States as a background for better understanding the program of work of the Station. If the Station is to be responsive to the needs of the region and help in solving them, there must be a close contact between the general progress of forestry in the region and the Station. It is not the intention to convey the impression that whatever progress in forestry has been made in the region during the last three years was due to the activities of the Station. It cannot be denied, however, that there is a mutual reaction between the Experiment Station and other forest agencies. Whatever hampers or stimulates progress in forestry, in general, makes the work of the Station so much harder or easier. Whatever retards the work of the Station must react to a smaller or larger degree also upon other forest activities.

Michigan

Of the three States, Michigan has unquestionably progressed farthest . This progress was not merely in actual work done, but in the expansion of general interest in forestry and of constructive thinking in many fields of conservation. The public mind in Michigan is at work and more and more is getting down to brass tacks on concrete problems and programs.

The Land Economic Survey, in which Michigan is leading the other States in the Union, although originated four years ago, has been fully developed, stabilized, and reduced to an efficient working basis within the last three years. Six counties have now been covered, each representing a group of counties more or less uniform in character. The counties thus surveyed are in the nature of samples, the results of which may be applied roughly to other counties of the same character. On the basis of the summary of results for these six counties, the Station is now attempting to obtain a picture of forest conditions in the State as a whole. One of the first official acts of the Station, after its creation, was the detailing of one of its technical men to the Land Economic Survey, both to assist and to learn of the methods and scope of its work.

Michigan was the first of the three States to actually pass a forest tax law, capable of wide application to cut-over lands. The law has many admirable features. Although only about 26,000 acres of cut-over land have come under the operation of this tax law, its passage removed one of the important psychological handicaps for the practice of forestry. Whether the law itself may require further modifications to make it more generally attractive, remains to be seen. At any rate, there is a forest tax law under which cut-over land may be placed if the owner seriously intends to devote his land to growing timber.

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There has been a marked improvement in the organization of fire protection in the State. There are now 124 towers, of which eight were added in 1926. Although some additional towers may be needed to make the system more complete, yet few of the present towers are unable to cross shots with one or two others. The fire equipment has been greatly increased. In 1926, 10 tractors and disc outfits were acquired and set to work constructing fire lines through and around State game refuges, similar to the fire lines built on the State Forests.

A great stimulus was supplied by a forest fire special train with exhibits diagrams, and lectures, which brought home to the people, in many small towns throughout the upper part of the Lower Peninsula and the Upper Peninsula, the importance of the forest fire menace and the necessity of combating it. The fire exhibit train reached 18,000 people in the Lower Peninsula and 32,000 in the Upper Peninsula, and is an outstanding example of educational work in the State.

Within the last few months, the Conservation Department has been reorganized with a technical forester as Director, and the organization of game refuges placed on a sound basis with the promise that other recreational interests will receive intelligent consideration.

The legal status of delinquent cut-over land is being investigated with the promise of early legislative action for correcting some of the existing drawbacks in conveying such land into the sole ownership of the State. The land colonization boom has collapsed of its own weight, and any land development is somewhat controlled by the State, through certification of the land as to its agricultural value. Land on the market, not so certified, is therefore at a disadvantage.

One of the most notable developments was the general approval of the reforestation program of the State and the large increase in the area planted. The total area of the State forest plantations now is 33,828 acres, and of this, 18,781 acres were planted within the last three years. There has also been a considerable increase in the State distribution of nursery stock for private planting.

Forest extension was recognized as an activity similar to agricultural extension, and a Forest Extension Specialist has been appointed on the staff of the Michigan State College.

The Forest School of the Michigan State College, in addition to its educational function in training foresters, has increased its research activities, partly through the acquisition of an experimental area at Dunbar near Sault Ste. Marie, and partly through cooperation with the Lake States Experiment Station in investigative projects.

The University of Michigan has shown renewed interest in forestry and has under way ambitious plansfor reorganizing its Forest Schoolon a substantial and comprehensive scale.

Through the efforts of thepeople of the Upper Peninsula of Michigan, a branch field station of the Lake States ExperimentStation was established near Marquette in Michigan. The land for the station has been deeded to the Government by the Cleveland-Cliffs Iron Company, and the money for the construction of a laboratory, headquarters, and other equipment provided by the Michigan Conservation Department.

As a result of the interest on the part of county officials in the preserva-

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(1) The information on the progress of fire protection in the three States was largely furnished by C. A. Hoar, District Forest Inspector, U. S. Forest Service.

tion of the natural beauty along many highways, several counties have made special appropriations, either for buying strips of virgin timber along the highways or planting trees where the timber has already been removed and eliminating slashings along the strips adjoining the highways. This led to the establishment in some counties of County Forests. The movement for County Forests is spreading, with Iron and Gogebic Counties in the lead.

As a result of the work of the Lake States Experiment Station, there is a general interest on the part of private timber owners in selective logging, and several companies have under consideration plans for applying this method of cutting to their regular timber operations.

Minnesota

The progress of forestry in Minnesota was steady but not of a spectacular character. The State fire protective system has been greatly strengthened. Several private fire protective associations have come into existence. Although the number of fires has shown a tendency to increase, the area burned over annually and the per cent of large fires has decidedly decreased.

One of the conspicuous advances in fire protection was the strengthening of cooperation between the State Forest Service and townships and organizations of timber owners. The law permits the towns to have township fire funds, obtained by a tax levy of not more than 5 mills. About one-half of the towns in the fire districts have such fire funds. The larger portion of these funds is expended by the towns for protection improvements, such as telephone lines. The State cooperates with 7 organizations of timberland owners, which either raise funds to be expended by the State or themselves direct protection efforts under the supervision of State rangers. These associations spend about $50,000 a year for prevention and suppression.

A rangers' school has been conducted during the past two years with very material improvement in morale and training of the rangers. The State conducted an educational campaign through the employment of a full-time lecturer during the last two years and also through the efforts of the field men, such as rangers and even patrolmen.

At the request of the Station, a special forest fire weather forecaster of the Weather Bureau has been assigned to the region, who in cooperation with the Lake States Experiment Station, State and private interests, established 8 fully equipped weather stations in Minnesota for predicting fire weather.

The original Forestry Board, made up of 9 members, appointed by the Governor to serve without compensation with overlapping terms, has been reorganized into a Conservation Commission, consisting of the Auditor (an elective officer), the State Game and Fish Commissioner, and the State Forester, the latter acting as the chairman of the Commission. It is too early yet to say whether this reorganization will prove more effective than the old Forestry Board.

Except for improvement in the fire protection system, Minnesota on the whole lagged in other forest activities. The State has no reforestation program and no money appropriated even for planting on State lands. The State forest lands are still being handled under the old system with practically no provision for regrowth or constructive program for State Forests. The State has no State forest nursery, and except for the nursery at the Cloquet Forest Experiment Station of the University of Minnesota no public source of suitable and inexpensive forest planting mate-

rial is available. The present policy of the Cloquet forest nursery is to restrict its output to its experimental needs. Agitation for a State forest nursery is now under way, and a bill has been introduced in the Legislature for the establishment of such a nursery, but its outcome is still uncertain.

A constitutional forest tax amendment was passed, and a joint legislative committee is considering the drafting of a bill to put into effect the provisions of this amendment.

The Forest Taxation Inquiry of the United States Forest Service started its work in Minnesota and has accumulated a large amount of valuable data as a basis for forest taxation legislation in general.

An Extension Forester has been attached to the Office of Agricultural Extension of the University of Minnesota, who is working in cooperation with the Forest School and the State Forester.

The Forest School of the University of Minnesota has made further progress under a new head; its enrollment is increased, and research activities both at the Cloquet Experiment Station and Itasca Park have been expanded. The experimental forest at Cloquet has been increased by the purchase of six additional forties and logging operations started on a systematic basis.

A CConservation Council, composed of delegates from the various organizations interested in conservation, has been organized, and represents some 250,000 members.

Another association, known as the Arrowhead Association, came into existence within the last two years, with the objective of developing the resources of the northeastern portion of Minnesota. It takes an active interest in conservation matters, and was particularly prominent in fostering the constitutional tax amendment. It is made up of organizations such as chambers of commerce and other organizations, in different towns and cities, and at present embraces representatioves from 28 villages, towns, and cities, and last year spent some $35,000 for the promotion of its work.

Wisconsin

Wisconsin, after a long period of inactivity, is showing revived interest in conservation and forestry. The forest fire protection organization has been considerably expanded, and new fire districts have been organized.

Where in 1921 there was only one fire protection district, today there are 7 districts. They still cover, however, only about one-third of the State, with only 7 or 8 rangers. There are now about 35 towers and about 400 miles of State-owned telephone lines for fire protection purposes. Much still remains to be done in the State of Wisconsin in fire protection alone. The improvements of the last 3 years in fire protection are briefly these: Number of fire districts has increased from 2 to 7; towers and telephone lines have at least doubled; trucks and tools, about one-half the quantity needed, have been bought; State funds have increased from $20,-000 to $70,000; educational work and law enforcement have been initiated.

The State passed an enabling act, authorizing the Government to purchase cut-over land for National Forests, and one purchase area, known as the Oneida purchase unit, has been selected.

A constitutional amendment for making possible State activities in forestry, such as purchase of land for State Forests, etc., passed by a big popular vote.

The Interim Tax Committee included within its scope of activities the forest

problem, and on the basis of its findings drafted a number of bills now before the Legislature.

A joint resolution was passed, authorizing the submission of a forest tax amendment to the people.

The State forest nursery and the State reforestation program have been slightly increased. The total area planted in the State is now about 6,200 acres, and, of this, 1,700 acres were planted within the last 3 years.

A bill is now before the Legislature for reorganizing the present Conservation Department and making it a board consisting of several members, serving without pay and having overlapping terms. This board is to appoint a Director of Conservation, who is to be responsible to the board.

The encouragement of land settlement in northern Wisconsin is now almost at a stand-still, and the State has practically abolished the office of Immigration Commissioner, whose function was to stimulate such land settlement.

Wisconsin leads the other two States in the number of progressive timber owners who are giving careful consideration to the proper handling of their forest lands. At least two large companies have availed themselves of the services of technical foresters, either for marking timber or for managing their forest lands, and there is general interest among the owners of hardwood land in selective logging. The sentiment is well expressed by a prominent timber owner in Wisconsin: "The timber owner is looking to the forester, whom he formerly mistrusted as an economic enemy, as his economic adviser."

An Extension Forester has been appointed on the staff of the Department of Agriculture at the University of Wisconsin, who is carried cooperatively by the University and the Conservation Department.

The authorization by the National Forest Reservation Commission during the past year of two purchase units, one, the Tawas unit in Michigan and the other, the Superior purchase unit in Minnesota, marks the beginning of purchase work in the Lake States region under the Act of June 7. 1924. It inaugurates a new policy, that of the purchase of lands for the production of timber, for heretofore lands have been selected only for the protection of streamflow. The establishment of several other purchase areas in Michigan and Wisconsin is under consideration, and the people throughout the region are keenly interested in this new policy.

The Work of the Station Becoming More Intensified

For the first three years of its existence, the energies of the Station were confined largely to a survey of forest conditions and general studies of the broad problems of the important forest types in the region, such as the yield of jack pine, the general fire situation as indicated by the statistics, the possibilities of aspen and birch stands, swamp forests, results of forest planting in the region, extent and possibilitis of "scrub" oak lands, and similar investigations. These studies, which were in the nature of "orientation" studies, gave a general picture of what may be expected of the existing forests in the future and helped to bring out the specific vital problems is need of further investigation. These general studies are now nearly completed. For some, the final reports have been prepared; for others, the field work has been completed and the preparation of reports is under way.

These studies involved considerable travel, covering all three States wherever a particular type of forest occurred. The method of approach was through a

large number of temporary sample areas which were measured and recorded, and the conclusions based on many such observations obtained in one or two years of field work. To cover a wide territory embracing forest types occupying several million acres in extent, the work had to be more or less extensive in character.

The map shows the character and distribution of our studies over the entire Lake States region. This shows that the region, except the western part of the Upper Peninsula, has been fairly well, although not uniformly, covered for all the three States.

With the completion of these general studies and the taking up of more fundamental problems at definite localities, or centers of work, more intensive methods become necessary. Within the last year the Station established its first series of permanent sample plots on the Minnesota and Superior National Forests, where records and observations will be extended on the same plots for many years to come. Additional permanent sample plots will be established on these Forests, in the hardwood forest at the Upper Peninsula branch station, on the State and National Forests in the Lower Peninsula of Michigan, at the experimental forest at Cloquet, and at other places for the study of specific problems.

These intensive studies will involve not merely observations on the growth of the stands but will go into the study of the causes of the differences in growth under one or another method of cutting and attempt to determine the relations between growth and reproduction on the one hand and the climatic, light, and soil factors on the other. The factors in need of study include climatic conditions, such as air temperatures, precipitation, humidity, wind, evaporation, frost, and length of the growing season. The light conditions should be measured by several different methods, since no one method at present has been proved to be entirely satisfactory. The soil factors would include current temperature measurements, both at the surface and in the deeper layers of the soil, the actual moisture conditions at critical dry periods, and the moisture holding capacity of the soils as determined by laboratory methods; similarly the soil reaction, its content of organic matter, nitrogen, and lime, and its biological activity should be determined both for the surface layer of leaf litter and humus, and for the different layers of underlying mineral soil.

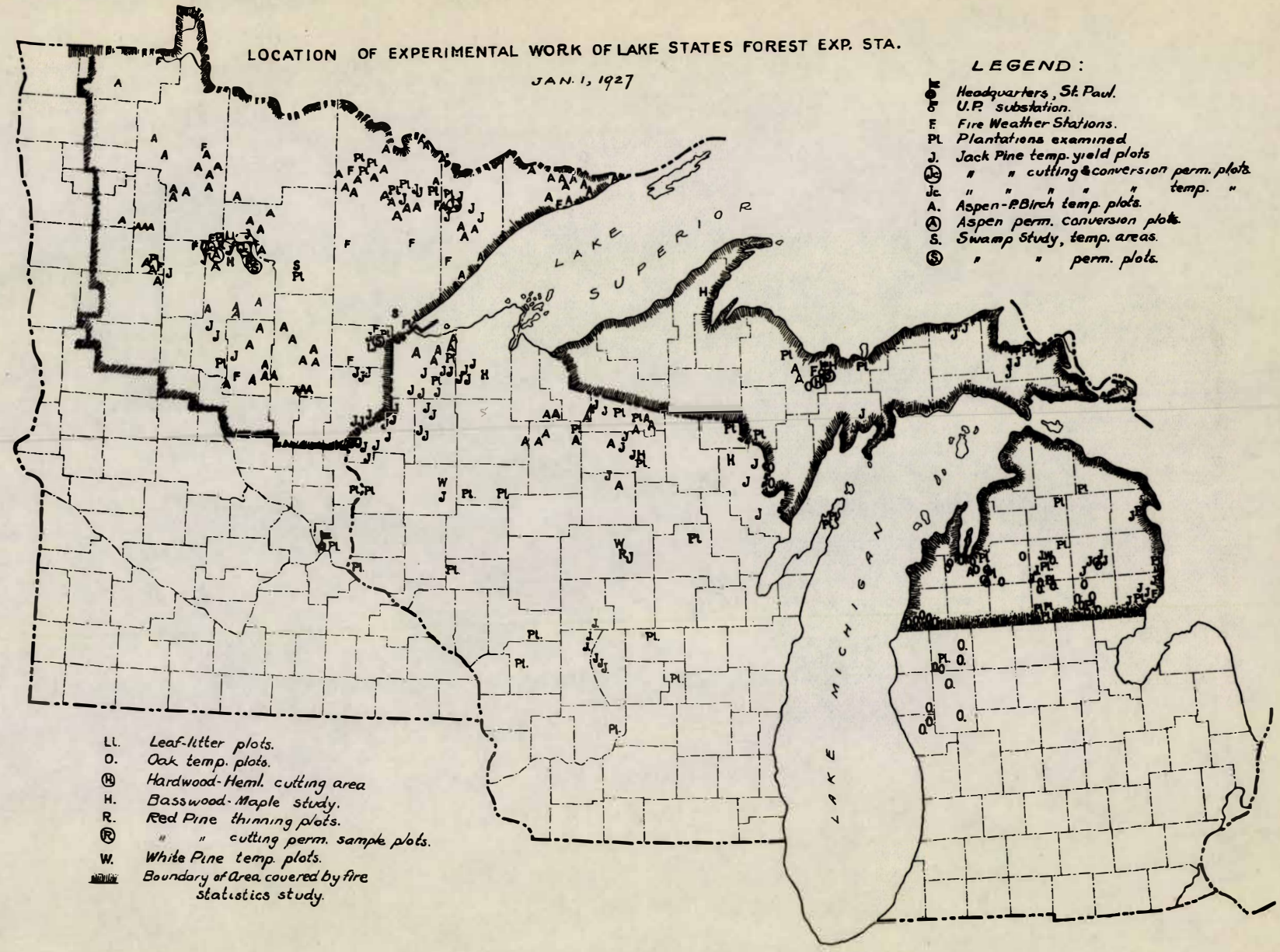
Already one season's records of air and soil temperature and wind movement have shown the marked differences in the local climatic conditions in the hardwood forest as compared with those in a nearby open area, differences which are doubtless partly responsible for the changes in the proportion of species and their growth rates on the cut-over lands. Still other conditions of climat reproduction, and growth will probably be found in the area of selective logging.

Measurements of light and soil moisture on the jack pine plots, where different proportions of the stand have been removed, may be expected to help to explain why red pine reproduction starts and grows on some and not on others. In the climatic and soil factors will likely be found the explanation of 6-inch jack pine, 60 years old, on the Superior with reproduction of spruce and balsam fir, and 7-inch jack pine, 50 years old, on the Minnesota with young growth of red and white pine.

In the swamps, instrumental and laboratory determinations will almost certainly be necessary to show the way in which lowered water levels act to promote growth and reproduction of the swamp species. These are only examples of the kinds of investigations which will have great value in helping to interpret the results which are obtained in the way of natural reproduction and growth, and in pointing the way

LOCATION OF EXPERIMENTAL WORK OF LAKE STATES FOREST EXP. STA.

JAN. 1, 1927



LEGEND:

- Headquarters, St. Paul.
- U.P. substation.
- F. Fire Weather Stations.
- Pl. Plantations examined
- J. Jack Pine temp. yield plots
- (J) " " cutting & conversion perm. plots.
- Jc. " " " " " temp. "
- A. Aspen-P.Birch temp. plots.
- (A) Aspen perm. conversion plots.
- S. Swamp Study, temp. areas.
- (S) " " perm. plots.

- Ll. Leaf-litter plots.
- O. Oak temp. plots.
- (H) Hardwood-Heml. cutting area
- H. Basswood-Maple study.
- R. Red Pine thinning plots.
- (R) " " cutting perm. sample plots.
- W. White Pine temp. plots.
- Boundary of Area covered by fire statistics study.

MILES
0 25 50 75 100

to modification of the methods which may give still better results in the future.

Such intensive studies must naturally be localized where facilities exist for carrying on continuous observations and records during consecutive field seasons. This brings to the front the need of centers of work, which until now have been of secondary consideration.

Centers of Work

The selection of suitable centers of work has a better basis each year as our knowledge of the region and its needs develops. There are, however, many complicated considerations, particularly in the way of facilities and funds, which still prevent the adoption or recommendation for a complete system of centers for the region.

The first essential for the intelligent selection of centers is, of course, a clear recognition of the differences in the natural conditions in different parts of the region. Analyzed in detail these differences include those of climate, geology, physiography, soil, and distribution of forest types and sites. The forest types in themselves are in expression of the combined effect of the influence of the various physical factors so that it seems certain that, if a careful analysis is made of the distribution of forest types in the region and centers are selected to represent typical type conditions, an adequate representation of the different physical conditions, will be obtained.

Starting on this basis, there are seven broad types which are important in the Great Lakes region. They are the swamp, white spruce--balsam, jack pine--red pine--oak, northern hardwood, aspen, white pine, and oak--hickory.

The oak--hickory type occupies the southern thirds of the three States and western Minnesota. For a time at least the work of this Station will not be concerned with the oak--hickory region, first, because that region of farm woodlots is already being covered to some extent and is the logical field for investigative work by the state colleges. The oak--hickory type in the Lake States is in the northern extension of the central hardwood region and with the establishment of an Ohio--Mississippi Valley Station, which will work largely in that type, the new Station might logically include the problems of the southern parts of the Lake States. No plans are, therefore, being made now for a center of work in the oak--hickory type.

The other types are all important and a system of centers of work should certainly aim to represent each of them and their major variations in composition and site. A brief account of the types represented at the different centers which have been established or suggested will show how far they meet the requirements.

In Minnesota, the Cloquet Forest has representative areas of jack pine and red pine on medium sites, of swamp, and a limited representation of aspen. The whole area, excepting the swamps, is situated on a sandy soil of a single soil type and of the same geological origin, namely, the young red drift. Work on the swamp drainage ,leaf litter, and fire weather projects is already in progress at Cloquet. Through the cooperation of the State staff, who are located there, and the excellent living conditions, it offers a particularly favorable opportunity for the conduct of experimental work which requires frequent observations throughout the season.

The Minnesota National Forest has typical areas of two sites of jack pine, red and white pine, of swamp, of aspen, of the southwestern edge of the white

spruce--balsam, and of the northwestern extension of the northern hardwood forest in which sugar maple and basswood are the chief components. Although much of the Minnesota Forest is on sandy lands, some of which are similar to those at Cloquet, it is on the young gray drift, a different geological formation, and, owing to its larger area, has much more variety of types and sites. Considerable work has been done and two sets of permanent sample plots in the jack pine and in the aspen types have been established on the Minnesota Forest.

The Superior National Forest in northeastern Minnesota contains large areas of the jack pine--red pine--white pine, aspen--paper birch, swamp, and white spruce-balsam types. There is also a scattering of the northern hardwood forest which is at its northern limit. A large part of the forest is located on shallow soils covering the crystaline rock formation which is not represented elsewhere in the region. Conditions in this part of Minnesota are so different from those elsewhere in the Lake States that a center of work on the Superior Forest will be essential. One series of permanent sample plots in jack pine were established in the fall of 1926. The Superior Forest has a large area which is only accessible with difficulty. It is desirable, therefore, to concentrate the experimental work as far as possible in some readily accessible locality within the Forest so that the work itself may be easily carried out and also that the experimental areas may be near one of the few traveled roads where they will also serve as demonstration areas. The area within a few miles of the Baird Ranger Station, about 20 miles south of Ely on the road to Finland, seems to offer excellent opportunities. The ranger station itself is not regularly used, and could be made available for the Experiment Station.

The center at Ruse in the Upper Peninsula of Michigan contains old growth and cut-over hardwood, swamp, and a little aspen, which are believed to be representative of a considerable area in the central part of the Upper Peninsula. This center was formally dedicated last summer, and work has already been started there. The future acquisition of land for a National Forest in the proposed purchase area to the south and east will greatly extend the possibilities of work from this center. Additional centers in the Upper Peninsula do not seem essential now, although there will undoubtedly be opportunities in connection with the establishment of county forests, which are being started in Iron and Gogebic Counties in the western part of the Peninsula, and in cooperation with the Michigan State College on its tract at Dunbar, south of the Soo.

Other centers are needed, particularly in Wisconsin and in the Lower Peninsula of Michigan, but definite recommendations for them have not been made. In Wisconsin, the State Forest with headquarters and a nursery at Trout Lake has representative areas of jack and red pine, aspen, and swamp types. About 20 miles east of Trout Lake, the proposed Oneida National Forest acquisition area, occupying the northern third of Forest County, contains a large area of hardwood--hemlock type within which was located one of the operations which was studied to obtain the relative costs of logging small and large trees. This Oneida purchase area is near the State Forest and they supplement one another in the types represented, so that they should probably be considered together as a single center of work.

Another possibility for a center of work is found in the region of Shawano, Wisconsin. It is representative of the hardwood--hemlock type at its more southern extension in the region, and in the area where the beech finds its western limit at

the edge of the limestone formation. It is in the belt where second growth white pine stands are most frequently found. It is near the Menominee Indian Reservation where the nursery, planting and logging operations may offer an opportunity for co-operation. If a center is to be established in this vicinity, however, it would be necessary to arrange for the donation of a suitable area of land which could be wholly under the control of the Experiment Station. The conditions in this part of Wisconsin are sufficiently distinct that a center of work is probably essential.

In the Lower Peninsula of Michigan, the Higgins and Houghton Lake state Forests near Roscommon have representative areas of jack pine, oak, aspen, and swamp types. In addition, there is the largest area and greatest variety of plantations to be found at any one place in the region . The State Forester of Michigan has already given us excellent cooperation in several projects and would be glad to have us make the Higgins Lake Forest a center of work.

Finally, the Michigan National Forest and the large extension of it, included within the surrounding purchase area, offers an opportunity for a center of work. Like the Higgins Lake Forest, it is chiefly on sandy lands where the jack pine--oak--red pine, and aspen types are represented. The extensive plantations also offer opportunities for experiments. Neither the State or National Forest in the Lower Peninsula, however, contain representative areas of the hardwood--hemlock type, so that it may some time be necessafy to consider still another center in the Lower Peninsula.

In order to show how well the above system of centers of work offers opportunities for the study of the forest type in the region, the following tabular statement indicates at what centers each of the types is represented:

Swamp	All centers, but especially at Ruse, Minnesota National Forest, and Cloquet.
White spruce--balsam	Chiefly on Superior National Forest ;also on Minnesota National Forest.
Jack and red pine	Superior National Forest for jack pine on the crystaline rock, Minnesota National Forest, Cloquet, Trout Lake for jack pine on sandy soils, Higgins Lake and Michigan National Forest for jack pine on poorer sils.
Northern hardwood	Chiefly at Ruse, Shawano, Trout Lake--Oneida.
Aspen	Superior National Forest, Minnesota National Forest, Trcut Lake, and Shawano.
White pine	Shawano (and elsewhere in plantations).

To cover all these conditions, eight centers of work seem to be necessary. If at all these eight centers intensive work is to be done every field season, it would be necessary to have at each of the centers a permanent research man. Manifestly, with our present limited personnel, this is out of the question. To meet this situation ,it is necessary to distinguish two kinds of centers of work, which will be conducted somewhat differently.

The extension of our work into the study of climatic, light, and soil factors will require daily or weekly observations through the growing season at centers where such projects are carried on. With a permanent staff of only 5 men, it will probably be impossible to assign men regularly and continuously to more than 3 centers. Therefore, work of this character apparently must be limited for the present to not more than three of the centers. One of them where such work has already been started is Ruse. A second might be at Cloquet, where we can count on the cooperation of members of the State station to help out in keeping the current observations if necessary. We are not yet ready to make recommendations as to the third center where work of this character would be carried on. At the other centers, it seems that the projects must be limited to the study of those factors which do not require current attention throughout the season. Permanent sample plots can doubtles be established at such centers, but the plots will have to be in projects which require only periodic examinations.

The Upper Peninsula Field Center

One of the most tangible accomplishments last year was the opening of a new field center or branch station in the northern hardwoods near Marquette, Michigan. The area comprises 320 acres of mature hardwood timber and 320 acres of cut-over land, donated to the government by the Cleveland-Cliffs Iron Company for the purpose of studying the hardwood forest and the problems of its management. The Company retained the timber but agreed to remove it within 20 years under the conditions specified by the Experiment Station.

The taking over of this tract for a field station involved some improvement work. On the building site an old logging camp had to be cleaned up, stumps had to be blown out, and the ground leveled. Considerable fencing had to be done. A combined office and laboratory building was oonstructed with the money provided for this purpose by the Michigan Conservation Department, to serve as field headquarters and laboratory. Appropriate signs were erected at each end of the highway bordering the station, and smaller signs were put up to designate the location and character of some of the experiments.

Aside from the physical improvement of the site, a number of experiments were undertaken. Weather observations were taken in the open and in the forest beginning in July to study the difference between the weather conditions in forests and cut-over land. Some interesting comparisons between the two situations have been brought out by the analysis of these records.

As a part of the study of the water level in swamps and its effect on forest growth, a swamp of about 25 acres in area was surveyed and ditched. The control of the water level in this swamp will permit accurate observations and studies on just how much the water level should be lowered for the greatest benefit to the swamp forest.

A 45 per cent cruise of the half section of virgin timber was made and a type

map drawn to show the distribution of different types of forest and the amount of timber in each. This cruise showed that the area and volume of the different types is as follows:

Type	Area Acres	Total Stand Board feet	Average per Acre Board feet
Hardwood (Heavy	177	2,068,200	11,700
Hardwood (Light	23	110,400	4,800
Hardwood--conifer	75	592,500	7,900
Coniferous swamp	12	74,400	6,200
Hemlock hardwoods	1	16,200	16,200
Alder swamp	14	---	---
Open	5	---	---
Total	307	2,861,700	9,300 average

In each of these types of forest, experiments will be conducted to find out the best way of handling it for the continuous production of forest products.

Selective logging was put into actual practice at the station in October when 20 acres of hardwood timber were cut.

Needs of the Station

The intensification of the Station work creates the need for an increase in scientific instruments and equipment, as well as for facilities for laboratory work. Some factors, such as climate and light, will be studied at the centers where members of the staff will be located, without need for other laboratory facilities; the forest itself in that case is the laboratory. Other factors, however, like soil determinations of moisture capacity, acidity, nitrogen, lime, organic content, and biological activity, must be studied in a laboratory where the soil samples, obtained from the permanent sample plots, will be brought to be analyzed. At present, the Station does not have a laboratory or greenhouse.

A small laboratory, such as is now needed, might be equipped if space is available for $500 or $1,000 and a greenhouse for as much more. Other Stations will or do need similar facilities. It appears that the time has come to consider seriously the establishment of a central laboratory for all the Forest Experiment Stations which could be adequately equipped, manned in part with the needed specialists in physical, chemical, and biological technique, and run much more economically and efficiently than separate small laboratories at each Station.

If such a central laboratory is not contemplated or feasible, our need is sufficiently urgent to justify the planning of a laboratory on a small scale for our own use. This matter is now being taken up with the University Department of Agri-

culture with a view to arranging for a laboratory and greenhouse in cooperation with the Division of Forestry.

Another need is for an increase in the number of Junior Foresters or scientific assistants on our permanent staff. Laboratory and greenhouse tests necessarily call for a large amount of routine technical work, just as field measurements call for a great deal of computation in the office. It is a waste of time and money to require the few older and experienced men in charge of the projects to perform the large amount of routine work which could be done by younger assistants. One of the great drawbacks in the training of our forest research personnel is the short apprenticeship which the younger foresters are getting. Altogether too soon they are put in charge of important projects, with the result that, later on, they have to be helped by the older men in completing their investigations and drawing the correct conclusions. The procedure should be reversed. The older men should be given as much assistance as possible in work of routine character. This would provide a longer period of apprenticeship for the younger men, so that when they do take up investigations of their own, they are better prepared to bring them to final completion.

This Station attempted to work up the computations of its field work by its own staff, instead of sending the data to Washington. While the latter procedure would relieve the Station of much routine computation, it feels that it is compensated by the quicker completion and the direct supervision of the work by the men who themselves gathered the field data and, therefore, can better interpret any deviations or exceptions. The Station feels that it could make better progress with the few older and experienced men it has and a number of assistants, than with more older men and practically no permanent assistants.

The Station repeats again this year its recommendation for the assignment of a forest biologist. The relation of the forests to wild life becomes increasingly important in the mind of the people, and at times even overshadows the importance of the forest as a mere source of raw materials. Hardly less important is the adequate study of the biological factors, the rodents, rabbits, and lower forms of animal life which are powerful agents in the regeneration of the forests. The relation between the animal life of many kinds and the forests can best be studied by a biologist attached to the Experiment Station, as the understanding of the life of the forest itself is essential for the understanding of the biological activities in the forest.

With the assignment last summer of a meteorologist from the Weather Bureau to work in cooperation with the Station, the need for an expert to forecast fire weather to aid in interpreting weather conditions, in terms of forest fire danger, has been met.

The Station's work on forest soils can probably be handled by a member of the staff, who in cooperation with the Division of Soils of the University of Minnesota has already done some work in interpreting differences in forest growth by differences in soil conditions.

In spite of the increased activities of the Experiment Station, which have increased both in scope and intensity, the appropriation for its work remains the same as it was at the time the Station was established. Some of the deficiencies have been eked out by cooperation with State forest agencies, forest schools, and private timber owners, but not enough to meet all the needs of the Station. An annual appropriation of at least $50,000 is needed to enable the Station to carry on its present work.

Cooperation

The Station, as in previous years, was fortunate in receiving active and financial cooperation from the State Forest agencies in the prosecution of its investigative projects .

The Department of Conservation of Michigan contributed $2,500 toward the development of the Upper Peninsula branch station.

The Cleveland-Cliffs Iron Company deeded a section of land for experimental purposes. This company also paid for carrying out the experimental selective logging of 20 acres at the Upper Peninsula branch field station. This involved the cutting of some 45,000 feet, board measure, of sawlog material at $10.50 a thousand and the cutting up of 250 cords of chemical wood at $4.00 per cord, or a total cost of $1,472. For this, however, the company was compensated by the value of the products obtained. which exceeded the cost of logging.

A private citizen contributed $250 toward the work at the branch station.

The Michigan State College contributed the services of two student assistants for nearly two months of field work on the study of the scrub oak, and also assistance in working up the field data during the winter; when measured in money this amounts to $560. The Agricultural Experiment Station of the Michigan State College contributed the equivalent of $200 in the form of labor and dynamite in the construction of 80 rods of ditches through the swamp forest at the Upper Peninsula branch station. The agricultural branch station of the Michigan State College, at Chatham, materially assisted in the development of our branch station by furnishing the dynamite, loaning a tractor and land-clearing tools, and giving the services of a land-clearing specialist.

The Forest School of the University of Minnesota cooperated with the Station in the aspen--birch study to the extent of $1,500. It assisted also in the study of the comparative costs of cutting large and small logs to the extent of about $300, in the form of the services of one of its instructors. The Division of Soils of the Department of Agriculture of the University of Minnesota made the chemical analyses of leaf litter. The Division of Engineering of the Department of Agriculture of the University of Minnesota, as a part of the cooperative swamp project, surveyed one of the swamps at a cost of $800, preliminary to its ditching.

The Bureau of Public Roads of the United States Department of Agriculture contributed $700 toward the survey and construction of ditches in a swamp on the Minnesota National Forest, as a part of our forest swamp project.

A sum of $570 was contributed by private interests and $500 by the Minnesota State Forest Service for the purchase of meteorological instruments for use in fire weather frrecasting.

The Minnesota State Forest Service assisted in computation of forest fire statistics to the extent of $150.

Although it is difficult to compute in terms of actual money, the financial assistance from all these agencies amounted during last calendar year to about $10,000, without counting the services of the forest entomologist, carried by the Division of Entomology of the United States Department of Agriculture and the University of Minnesota, and the forest pathologist, supported entirely by the University of Minnesota.

In addition, the Station cooperated with the Department of Botany of the University of Chicago in providing opportunities for field work for two of its graduate students working for doctor's degrees,and with other departments of the University

of Chicago and the State Universities of Wisconsin, Michigan, and Minnesota.

Results of Last Year's Work

The Station during last year completed five investigations and carried eight active research projects. The main active projects were: (1) Fire Studies, (2) Methods of Cutting in Northern Hardwoods, (3) Possibilities of Aspen--Birch Lands, (4) Effect of Water Level in Swamps upon Forest Growth, and (5) Insect Investigations. The minor active projects were: (6) Methods of Cutting in Jack Pine, (7) Possibilities of Scrub Oak Lands, and (8) Study of Forest Leaf Litter.

Investigations Completed

The manuscripts on "Timber Growing and Logging Practice in the Lake States", "A Handbook of Forest Planting in the Lake States", and "Yield of Jack Pine in the Lake States" have now been submitted for publication. Reports on "Thinning in Red Pine on the Minnesota National Forest" and "Management of the Maple--Basswood Type on the Minnescta National Forest" have been written up.

Investigations Under Way

1. Fire Studies.

Of the two fire studies on the Station program, namely, the analysis of fire statistics and the study of fire weather, the former is now nearing completion. During the past year the data obtained from over 12,000 individual fire reports has been tabulated and analyzed and a report covering the situation in Minnesota is in course of preparation.

Work on the fire weather study has also been going forward, an intensive field study being made last spring, in cooperation with the Minnesota State Forest Service, of weather conditions affecting the occurrence, spread, and intensity of fires. Observations of weather and fire conditions have also been continued at the 12 cooperative stations previously established in cooperation with the state and federal Forest Services. Considerable impetus has been given this work by the assignment to the region of a special forest fire weather forecaster by the Weather Bureau and the cooperaion of State and private interests in the establishient of eight fully equipped cooperative weather stations under his direction. The Station equipment for use in fire weather and similar studies has also been increased by the purchase of three complete sets of weather instruments, consisting of anemometers of the latest type, maximum and minimum thermometers, instrument shelters, and rain gauges; also three duff hygrometers for determining the moisture content of duff and leaf litter; two Pisch evaporimeters; and 20 porous cup atmometers for measuring the rate of evaporation under different conditions of cover and weather. Arrangements also have been made with the Minnesota and Superior National Forests to purchase hygrographs for local use, thus releasing the Station-owned instruments loaned them, for use elsewhere. Considerable further work on this project will be necessary before conclusive results will be available .

The study of forest fires in Minnesota brings out clearly the size and importance of Minnesota's forest fire problem, the conditions involved, and the fin-

ancial justification for protection. It shows what the trend of the past few years has been. and analyzes the present situation in detail. In short, it attempts to furnish a scientific basis for adequate protection. Briefly ,the facts are these:

Minnesota has normally from 1,000 to 1,200 fires a year, burns over in the neighborhood of 400,000 acres annually, and suffers an average loss of close to a million dollars a year. During the past ten years, the average annual number of fires has increased over 100 per cent. Thanks to better protection, however, the average area burned has decreased 25 per cent, and the size of the average fire 63 per cent.

While logging and fire have reduced Minnesota's forest resources over 85 per cent, the State still has in the neighborhood of $115,000,000 worth of merchantable timber and is producing approximately $2,250,000 worth of pulpwood and saw timber annually. Capitalized at 3 per cent, the present production value of growing timber is over $90,000,000, which places the present total forest wealth of the State in need of protection at over $200,000,000. The estimated cost of adequate protection, on the other hand, is, in the judgment of State and Federal forest officers, only about $650,000 per year, or approximately .3 of one per cent of the values involved. With adequate protection, the areas now idle will become productive and the average yield per acre of culled-over and second-growth stands may be expected to increase at least 50 per cent as existing open stands become more fully stocked. Allowing for a 10 per cent reduction in the present forest land area by settlement, a conservative estimate of the potential annual wood production to be expected with adequate protection from fire is in the neighborhood of 7,000,000 cords or 3,500,000,000 feet board measure, more than twice the amount now being produced.

The fire situation is most serious along railroads and highways and in the regions where logging and agricultural development is under way. Other factors, however, such as the character and conditions of the forest cover, climate, local sentiment toward forest protection and the effectiveness of local protective effort tend to modify this situation. The actual condition to be met, therefore, is indicated by the prevailing risk. This has been worked out for each of the established protection units and by 10-day periods, months, and seasons. The results show that while the average risk of fires starting, or risk of kindling, for the area under protection as a whole is 3.5 fires per 100,000 acres, it varies from 1.5 to 8.9 between districts.

The size of the average fire also which is a measure of the risk of spreading as determined by character and condition of cover, climate, and effectiveness of protection, also varies between districts from 120 acres in the least hazardous to 630 in the most hazardous, the average for the State being 360 acres. A combination of these two kinds of risk is obtained by dividing the average area burned annually by the total area under protection. This gives the per cent of the protected area burned annually. For the protected area as a whole, this amounts to 1.3 per cent, based on the records of 10 years, while for individull districts, it varies from.3 per cent to 2.9 per cent.

The loss per acre varies between districts in proportion to the values involved and the average intensity with which fires burn. The range in Minnesota is found to be from 50 cents per acre on the Minnesota National Forest to $8.54 per acre in the region about Little Fork, while the average for the protected area as a whole is $3.10. In order to properly rank the various protection units according to

the risk involved, a combined rating is obtained by dividing the average annual loss by the area under protection. This takes into consideration all three of the base factors, namely, number of fires, average size, and loss per acre. The result, expressed as loss per acre protected, serves as a guide not only to the administrative officer in charge of protection in allocating protection funds but to the investor in forest property who desires to know what risk he runs of loss by forest fires. For the whole area under protection, this amounts to 4 cents per acre, while for individual districts it varies from 0.3 to 14.3 cents.

As to the seasonal occurrence of fires, the experience of the past 10 years indicates that forest fires may be expected at any time from the time snow leaves the ground in the spring until it comes again in the fall. Normally, however, the fire season starts with the second 10 days of April and extends through the first 10 days of November, with distinct lulls during the last 10 days of June and second 10 days of September. These lulls serve to divide the fire year into distinct spring, summer, and fall fire seasons of which spring is the worst, fall next, and summer least severe. About 51.1 per cent of the fires, 56 per cent of the area burned, and 53.5 per cent of the total loss occur in the spring; 20.8 per cent of the fires, 27.6 per cent of area burned, and 30.5 per cent of the losses occur in the fall; while 28.1 per cent of the fires, 16.4 per cent of the area burned, and 16 per cent of the losses occur in the summer. While summer exceeds fall in per cent of fires, it falls well below it in per cent of area burned and per cent of loss. Comparing the three seasons on the basis of area burned per fire, it is found that fall fires are the largest, spring fires second, and summer fires third in size, averaging 496,412, and 218 acres respectively, while on the basis of loss per acre burned, fall fires come first, summer fires second, and spring fires third, the destructiveness of fires in the different seasons being $3.42, $3.01, and $2.97 per acre respectively. Thus, while in the spring fires are most numerous and the total loss and area burned are greatest, the largest and most destructive fires occur in the fall. Summer fires also are more destructive than spring fires. Taking all things into consideration, however, spring is normally the season of greatest risk as shown by comparing the three seasons on the basis of loss per acre protected; the figure for spring being 2.2 cents, for fall 1.2 cents, and for summer but .6 cent.

The study includes also an analysis of the causes of fires as to relative importance and seasonal occurrence; the relation of suppression expenditure to area burned and damage and other special phases of the fire problem.

A similar report covering the forest fire situation in Michigan is in course of preparation. The incompleteness of the data, however, may make it necessary to postpone its publication until the statistics for additional years can be compiled and included.

2. Methods of Cutting in Northern Hardwoods

With the opening of a center of field work in the hardwoods last summer, the opportunity was offered to develop this investigation on a comprehensive scale. Twenty acres of a virgin maple and yellow birch forest were logged selectively during the winter of 1926. A complete cruise of the entire 20 acres showed a total stand of 127,000 board feet. Under the plan of removing about one-third of the stand, some 45,000 feet of logs, Scribner scale, were marked for cutting, or 2,250 feet

from a total stand of 6,350 feet per acre, or 35 per cent of the total stand by volume. The actual scale of the timber cut proved to be 45,127 board feet, and in addition about 250 cords of chemical wood.

The average number of trees per acre was 193, ranging from 3 inches to 36 inches and over in diameter breast high. No trees below 22 inches in diameter were cut, except where their removal was considered beneficial to the remaining stand. In all, 169 trees were cut on the 20 acres. In addition, 89 trees were broken down in felling the larger trees and had to be cut up into chemical wood. On an average acre, 8 trees were cut and in addition 4 trees were destroyed in logging, the latter ranging between 3 and 15 inches in diameter. Only 3 trees above 12 inches in diameter on the entire 20 acres were broken in logging and had to be cut into chemical wood. Out of an average stand of 193 trees per acre, there have been removed, therefore, 12 trees per acre, leaving 181 trees to the acre. Of these, there were 41 trees 12 inches and over in diameter. The loss through breakage in logging the larger trees was remarkably low, about 2.2 per cent of the number of trees remaining, but an insignificant per cent of their volume. If this loss is compared to the ordinary loss of small trees in logging, where 68 per cent of all the trees between 3 inches and 6 inches are destroyed and 38 per cent of all the trees between 6 and 12 inches are destroyed; this is a remarkable showing, and proves that selective logging does not involve great damage to the remaining trees, even when no unusual precautions are taken in felling.

A most striking result of the selective logging is the high quality of the product obtained. This made possible the removal of one-half of the value and only one-third of the volume of the stand. The average value of hardwood logs cut in ordinary logging operations during last winter was about $19 a thousand feet on the cars and in some localities even lower. For the logs cut under selective logging, the maple logs were worth $26.50 per thousand and the birch $33. Since there were cut 6,000 feet of birch logs and 39,000 feet of maple, the average value of the logs cut on the 20 acres was $27.50 a thousand. Had the entire stand been cut, the value of the logs at $19 a thousand would have brought $120.50 per acre. By taking only 35 per cent of the volume from the largest trees, the value of logs was about $62 per acre.

The chemical wood, produced from the tops and defective portions of the trees and from smaller defective trees, will aggregate about 250 cords. At 50 cents a cord stumpage for this material, the chemical wood brought in an additional $125, or $6.25 per acre.

Log Grades Produced in Selective Logging

	Veneer		Bowl logs		Woodenware	
	Bd. Ft.	Per cent	Bd. Ft.	Per cent	Bd. Ft.	Per cent
Maple	12,531	32.1	18,991	48.8	7,526	19.1
Birch	3,005	49.0	1,917	31.3	1,202	19.7

Another significant feature of last year's selective logging was the logging cost. It compared favorably with the logging costs over large areas and on an average was even a trifle lower. The contract was awarded to a local settler who charged $10.50 a thousand feet for felling, skidding, hauling, and loading the logs on the cars, and $4 per cord of chemical wood, including splitting, hauling, and loading on cars. The proceeds and the logging costs on the 20 acres are as follows:

Receipts from Selective Logging

45 M feet logs @ $27.50	$1,237.50	
Cost of logging @ $10.50	472.50	
Receipts from logs after deducting logging cost		$765.00
Receipts from 250 cords chemical wood @ 50 cents stumpage		125.00
Total receipts from 20 acres		$890.00
Receipts per acre		$44.50

This, of course, does not include carrying charges on the investment.

Another feature of selective logging was the fire-proof condition in which the forest was left. By cutting only trees over 22 inches in diameter and by utilizing the tops down to 3 inches for chemical wood, there was very little slash left on the ground. This will remain moist in the shade and will soon rot. Except for the scattered stumps, there is little to indicate that one-half of the value of the stand was removed from the 20 acres. The stand has the appearance of a virgin hardwood forest. Since the forest conditions were left intact, it means that the air will constantly be moister here than if it were cut clear, that the surface soil will remain cooler and damper throughout the critical spring and fall fire season, as well as through the entire summer.

Another fact of importance is that the logging was done by a local settler, to whom the winter work was a source of income, affording him the opportunity to develop his farm during the summer with the assurance that he will remain a permanent settler.

In another 20 years the 41 trees between 12 and 26 inches in diameter left per acre under selective logging will grow from 2 to 4 inches in diameter. The amount of growth will more than make up for the 2,250 feet removed in the selective logging. In 20 years the growth of the trees left now will bring the stand back to its original volume, and it should be possible to make another selection cut at that time of as high quality timber and get at least a similar income. With selective logging, then, the forest will be continuously productive, bringing in according to this example $44.50 an acre every 20 years, or $2.22 net per acre every year, not counting carrying charges.

Last year's selective cutting, although not by any means conclusive because of only one year's cut, opened, however, perspectives and possibilities worth while considering. Many lumber companies, laying out their logging operations, leave the tracts nearest the mill and accessible to the means of transportation toward the end of their operations. This is especially true of the Cleveland-Cliffs Iron Company holdings, where many accessible forest areas are left at present untouched. These tracts may not be cut for another 25 or 30 years. Meanwhile, there are taxes, protection, interest on the investment, and other carrying charges to pay. At present the net growth of these old stands is nil, the growth being offset by the natural decay. If these tracts should be cut over selectively, like the experimental tract last year, the bulk of the investment could be removed and yet two-thirds of the

stand left in a good growing condition, producing from 125 to 200 board feet per acre per year. At the time when these tracts are to be cut ,that means within the next 25 or 30 years, the stand will be fully as much as it is today and the likelihood is that the timber will be of better quality.

There is another consideration in that these accessible tracts are surrounded, here and there, by settlers who are trying to make a living on the land. It is these settlers who would be engaged in the selective logging of these accessible tracts continuously, and whose position would be strengthened as permanent settlers and farmers.

At present, there is a double waste. At one hand, logging at the end of the logging road, miles away, is wasteful and destructive to the future of the forest. On the other, there is the waste caused by the loss of growth in the old stands accessible to transportation and towns. This double form of waste could be greatly reduced by the adoption of selective logging, as illustrated by the cutting of last year.

The investigation as to the comparative costs of logging small and large trees, which is a part of the study of Methods of Cutting in Northern Hardwoods, is now completed, except for the preparation of the final report.

3. Possibilities of Aspen—Birch Lands.

The completion of the field work in the study of aspen and paper birch during the past season does not change the estimate previously made that about two-thirds of the area of forest land in the northern parts of Minnesota, Wisconsin, and Michigan is occupied by this type, and that only 10 or 20 per cent of the area of the type has an appreciable representation of pine, spruce, or other conifers in mixture with or coming up under the aspen and birch. The situation is different in northeastern Minnesota, where the large areas of National Forest and State land have resulted in better protection from fire so that the conifers have had a better chance to become established and develop under the aspen and birch. In this section it is estimated that 30 per cent of that type has a fair representation of conifers.

The balsam, pines, and spruce grow slowly under the shade of the aspen but apparently they persist remarkably well and in most cases give promise of living until the aspen dies out when the longer--lived conifers take possession of the land. It is unfortunate that repeated fires have covered so much of the cut-over pine lands and destroyed the small growth of conifers which might otherwise be occupying these aspen--birch lands with great promise for the future. The fires have done their work, however, and on a large proportion of the aspen--birch lands planting will be necessary to restore the pine or spruce in any reasonable period.

Volume tables have been completed for aspen of different heights and diameters in terms of total cubic feet, merchantable cubic feet, cords, and board feet by the Scribner Decimal C. and by the International log rules. Five hundred eighty-four trees were available as the basis for these tables, which were prepared by S. R. Gevorkiantz who has worked part of the time as a member of the Lake States Station and part of the time as a member of the Cloquet Station, the project being a cooperative one. The tables for aspen have been published in Technical Bulletin No. 39 of the University of Minnesota Agricultural Experiment Station, "Tables for Determining the Contents of Standing Timber in Minnesota, Michigan, and Wisconsin."

Similarly, preliminary volume tables for paper birch in total cubic feet,

merchantable cubic feet, and cords have been prepared. The paper birch tables have been given limited distribution to those who needed them most urgently. The preparation of these tables almost completes one phase of the project.

A second phase, namely, the development of rot in the aspen stands and its relation to the size and age at which aspen should be cut has been studied by Professor Henry Schmitz of the Minnesota Forest School as one of the cooperating agencies in the project. The study of heart rot in aspen was based on 640 sample trees selected from 118 sample plots distributed throughout the range of the species in Minnesota. The results of this investigation indicate that the period of greatest production of net sound wood occurs at approximately 70 years. Since the greatest periodic growth also occurrs at 70 years, it is doubtful if decay will materially influence the length of the rotation for aspen.

Three stages of decay are recognized: incipient, intermediate, and final At 70 years the total rot (i.e. incipient, intermediate, and final) amounts to 31 per cent of the total merchantable volume; intermediate and final rot to 21.5 per cent, and final rot, 7 per cent.

If aspen is grown on a 40 or 50-year rotation and if these stands receive fire protection and are given such silvicultural treatment as to insure rapid growth, decay will not be a very serious factor in its production. On such rotations anticipated yields should be reduced from 2 to 10 per cent in order to allow for cull from decay.

The analysis of the growth as far as it has been carried indicates that the trees in well-stocked stands of aspen will have the following average diameters at breast eight at ages of 40, 50, and 60 years.

Growth of Aspen

Age	Site		
	Good	Medium	Poor
Years	Average d.b.h.		
40	5.4	4.5	3.5
50	7.1	5.9	4.6
60	8.9	7.6	5.8

In order to study the effect of different degrees of cutting on the growth of the trees left and on the establishment and growth of white pine and white spruce, four permanent sample plots on the Minnesota National Forest were installed. One was cut clean, a second had 50 per cent of the aspen removed, a third, 30 per cent removed, and a fourth was left uncut. Tho trees left on each were tagged with numbered metal tags, so that their future growth and development may be recorded. The natural reproduction of white pine from seed trees was ccunted and marked on strips across each plot. White pine and white spruce seed was sowed in spots partly on the natural leaf litter, partly with the litter scraped off, partly with wire screens to protect the seed from rodents and partly without screens. A portion of each plot was fenced to see if the snowshoe rabbits are responsible for the scarcity of natural white pines of larger than seedling size. These plots will be examined periodically and conclusions from them will be available only after a few years.

The completion of the project, except for the permanent sample plots, awaits

the finishing of the study of growth and yield for well-stocked and understocked stands, the analysis of the evidence on the conversion of aspen--birch stands to pine and spruce naturally and by planting, and the preparation of a publication to make the results available.

4. Effect of Water Level in Swamps on Forest Growth.

Two forested swamps, one on the Minnesota National Forest at Cass Lake, Minnesota, and one at the branch station at Dukes, were ditched last year for the study of the effect of water levels in swamps upon forest growth.

Another swamp at the Cloquet Station was intensively surveyed, 52 observation wells installed, maps prepared, and plans made for the main ditches at a cost of some $800. The swamp that will be ultimately drained covers from 250 to 300 acres; the immediate drainage is to be confined, however, to about 180 acres. The estimated cost of ditches will be in the neighborhood of $3,500 or at the rate of $14 per acre for the entire swamp. Because of the cost, the actual ditching of this swamp was postponed for another year, and the work last summer was confined to recording the periodic fluctuation of the water levels in the wells.

The swamp on the Minnesota Forest is about 11 acres in extent with a typical stand of slow-growing spruce. It was selected for water level studies because it is not only typical of the black spruce type of swamp, as found in Northern Minnesota, but it is also small enough so that it was easily drained and can be kept under exact control.

During last May and June the swamp was surveyed and the drainage planned. At the same time 13 observation wells were installed, so weekly readings of the water level could be taken throughout the swamp. These observations were taken by Forest Ranger Soderbeck during the summer and fall until November 19, when the water was frozen in a number of the wells.

A system of ditches was installed during October by D. G. Miller and R. G. McGrew of the Division of Agricultural Engineering, Bureau of Public Roads. In order to provide for various degrees of drainage, the ditches were dug deep enough to lower the water level in the swamp 3 feet. Dams were installed, however, in two places so that the water can be held at any desired level.

The main ditch is 3 to 3½ feet deep, two long branches are 2 to 3 feet deep. and two short branches are 1 to 2½ feet deep. Altogether 3,800 feet of ditch was dug of which 3,100 feet is in the swamp; only a 700-foot outlet ditch being required to lead the water out of the swamp.

Digging by hand was the method used to construct the ditches which for the most part went through the un-timbered parts of the swamp. The digging was, therefore, comparatively easy as no trees, stumps or brush had to be removed.

The total labor cost in constructing the ditches was $199, which is a cost of 87 cents per rod. These costs do not include any charges for supervision or the survey as both of these items were unusually high on account of the experimental nature of the project. Since the swamp is 11 acres in area, the cost per acre for the actual drainage was about $18.

More ditches were put in than were absolutely necessary for forest drainage purposes, and they were made considerably deeper than necessary so the experiments could cover drainage to various uniform depths throughout the swamp. For practical forest drainage of such a swamp, probably only the main ditch with two short later-

als would be needed and they could be much shallower. The cost, therefore, under practical drainage would be much less. This swamp is so susceptible to drainage that as soon as the ditches were completed the water level fell in the swamp one one foot . The dams were then installed to hold the water at this level.

At the branch station in the Upper Peninsula of Michigan the swamp selected for the study of water levels and tree growth borders the main highway and contains a variety of forest types, ranging from spruce muskeg to cedar and tamarack, and black ash, red maple, and balsam. It is about 40 acres in area, and part of it has been cut over and part of it is intact, so the effects of the drainage on these different types and conditions will give valuable comparisons.

This swamp was ditched by means of dynamite as the undergrowth, stumps, and fallen trees were too dense for economical hand ditching. One main ditch, 1320 feet long, was installed which will drain about 20 acres. From this main ditch laterals can be extended when desired to increase the area drained and the degree of the drainage.

In constructing the ditches by blasting, a line had to be blazed through to mark the ditch. Then one row of charges were placed in the ground 18 inches apart, each consisting of one-half pound of 50 per cent straight nitro-glycerine dynamite and one-third pound of pyrotol.

The cost of this drainage work was $1.74 a rod, of which labor cost 33 cents; the rest being the cost of the dynamite and pyrotol. Since 80 rods of ditch were put in and this probably will drain 20 acres, the cost per acre was $6.96.

Wells for reading the water level were installed in this swamp also at 14 different points and readings were taken weekly beginning the last of August. In addition, a weather station was set up where daily maximum and minimum air temperatures were taken and also the soil temperatures.

Dynamite blasting and hand digging for ditch construction are not properly compared in these two operations. The swamp on the Minnesota National Forest was easy to ditch on account of the open nature of ground where the ditches were put in. The swamp on the station at Dukes, on the other hand, was difficult to ditch on account of the dense growth and fallen trees and stumps. To compare the two methods, ditching by blasting and by digging should be done under similar conditions.

Besides the work in the field, a bibliography of over 4,000 titles, dealing with the swamp problem, has been collected.

Permanent sample plots for studying the effect of water levels on the forest growth will be established in each of the drained swamps at varying distances from the ditches. The water level records will be continued throughout the coming season in all three swamps, and at the branch station soil and air temperatures will also be kept. In addition, samples of peat from each swamp will be analyzed to determine its character and chemical composition.

The records of the swamp which was drained in 1910 at the Grand Rapids Agricultural Experiment Station in Minnesota will be analyzed and correlated with the increased growth which occurred in the forest. The results will be made available for publication.

5. Forest Insect Investigations

The forest insect investigations in the Lake States are conducted cooperatively by the Division of Entomology, University of Minnesota; the Bureau of Entomology, United States Department of Agriculture; and the Lake States Experiment Station,

under the direction of Dr. S. A. Graham. The Minnesota Commissioner of Forests and Fire Protection has also cooperated in certain portions of the work and has been of material assistance in many ways.

No new projects have been started during the past year because of lack of funds. The work at present is primarily concerned with studies of defoliating insects. The ultimate aim in mind is to develop effective and economical methods of controlling these pests. Incidentally, as time permits, observations are being made upon the bronze birch borer, and some work is being done on insects in green logs and pulpwood. Each of the principal projects will be taken up individually.

THE SPRUCE BUDWORM. The spruce budworm attacks firs and spruces and kills the trees by repeatedly defoliating them. This same species also attacks jack pine, but the budworm on jack pine appears to be a biological variety and can be treated from the viewpoint of control as a separate species.

The investigations of the spruce budworm are designed primarily to determine the effect of forest composition, soil, parasites, predatores, and other environmental factors upon the abundance of the insect, and also the effect of defoliation upon trees growing under different conditions. The records are taken on a series of sample plots which are examined each year. The plots have not been established long enough to form the basis for very definite conclusions as yet, but general observations and preliminary studies have shown that balsam fir and white spruce appear to be the key species, and that the regulation of the proportion of these speciesof trees in a forest will probably form the basis of future budworm control.

The series of active outbreaks of the budworm in northern Minnesota, that have been in progress for the past 13 years, has apparently reached an end. There was very little defoliation this past season, and, as a result of this and the excellent growing conditions that were general throughout the budworm area, the condition of the trees that have survived appears to be much improved.

One of the most important factors that have contributed toward bringing the budworm outbreaks to a close is the control influence exercised by the bird residents of the infested region. Many species of birds, particularly the warblers, feed freely upon the budworm. These birds are now very abundant in the forests of northern Minnesota.

Although the active budworm outbreak has come to an end at least some trees will continue to die. Some of those that have been very severely injured as a result of defoliation will be unable to recover from this injury, and others that might recover from defoliation will be killed by secondary insects, such as the balsam bark weevil, the balsam bark beetle, and the balsam sawyer. These secondary insects are now on the increase as a result of the favorable food conditions that now exist in the areas where trees are weakened and dying from defoliation. All these phases of the problem are being studied.

Another serious feature of the budworm outbreak is the effect that the heavy thinning caused by the death of the balsam fir and spruce has had upon the birch that remains. These trees are now succumbing to the attacks of a boring beetle, the bronze birch borer. This insect is usually not dangerous in a fully stocked forest, but it is believed that when the trunks of trees are exposed to full sunlight they are almost certain to be killed eventually by the borer. This is one of the serious after effects of budworm outbreaks that should be studied fully, but which we have thus far been able to work upon only in a very cursory way.

Like the spruce budworm on balsam fir and spruce, the form of this insect on jack pine decreased in abundance during the past season. This reduction in numbers, coupled with the excellent growth made by the trees, has made a great improvement in the general appearance of the forest. In fact the effects of the previous years of defoliation have disappeared to a considerable degree. Observations on the sample plots established make it possible to compare the abundance and the amount of defoliation from year to year.

Experiments carried on during the season just passed have still further strengthened the theory that the budworm on jack pine is distinct biologically from the form on balsam--fir and spruce. They indicate that the choice of hosts is made by the adults. The moths that have been reared on jack pine prefer jack pine and select that tree for egg laying if they have opportunity to exercise a choice. The same is true of the moths that have been reared on balsam fir or spruce. They prefer the host upon which they fed as larvae.

THE JACK PINE SAWFLY. This insect was somewhat more injurious during the past season than in the previous two years. It is interesting to note, however, that the number of eggs, laid each fall since this species has been under observation, has been sufficiently heavy to produce a serious outbreak if the larvae that hatched therefrom were permitted to develop under favorable conditions. Such an outbreak has only been prevented by weather conditions that were adverse to the insects.

For instance in 1923 a very serious cutbreak occurred. In 1924 the stage was set for another bad season. Fortunately, however, the weather in early June was cool and the larvae developed very slowly. In mid-June, when the larvae should have been full-grown, they were only half grown and the growth of the trees had compensated to a considerable degree for the damage done up to that time. Then came a warm spell and at the same time a disease appeared among the sawfly larvae and destroyed almost all of them.

Enough females survived, however, to provide an abundance of eggs for the next year 1925. In that season heavy rains in early June washed the larvae from the trees and prevented serious injury. In 1926 the stage was again set for an outbreak and the dry-warm weather of May seemed favorable for the insects. The eggs hatched early and the larvae flourished for a time but were greatly reduced in numbers by heavy late frosts. Thus, weather conditions have intervened each year since 1923 to prevent serious damage by this pest. It is apparent that thejack pine sawfly situation is likely to become serious almost any year. All that is needed to touch off the fuse is a combination of favorable weather conditions that eventually are certain to occur. Our chief problem is to find means of reducing the danger of such an outbreak.

THE LARCH SAWFLY. Another important forest insect in the Lake States is the larch sawfly. Time has not permitted us to give as much attention to this dangerous pest that has killed since 1900 over 60 per cent of all the merchantable tamarack in the Lake States.

This pest has been quiescent for a number of years but now appears to be on the increase. Careful counts, however, show that during the past five years the proportion of green tips in which eggs have been deposited has remained approximately the same. The same increase in defoliation may, therefore, be the result of the action of favorable environmental factors. What these factors are has not been determined.

Hibernation experiments this past season have further substantiated the belief that the larch sawfly is very exacting in its requirements for successful hibernation. Only under conditions, such as those found in the moss under the swamp trees, did the cocooned larvae winter successfully. This would seem to indicate that tamarack grown on the upland may suffer comparatively little injury from this pest.

One of the important agencies that help to control this sawfly is the feeding activity of mice. These rodents collect the cocoons of the sawfly just as they do seeds and feed upon larvae or pupa. No satisfactory method of studying the effect of this factor quantitatively has been worked out as yet, but it is hoped that something of the kind may be accomplished in the future.

THE BRONZE BIRCH BORER. This insect, as has been pointed out previously, is very serious in the forests thinned out by the spruce budworm. It is also a problem in over-mature stands and in forests that are growing on poor quality sites. A few sample plots have been established to study its effect in the last mentioned condition, but they have not yet yielded conclusive results.

The importance of this insect is now coming to be generally recognized, and it will doubtless be an important consideration in the management of hardwood stands in this region. Therefore, it is hoped that additional funds for the forest entomological work can be obtained so that studies of the relation of this insect to different systems of forest management can be studied.

INSECTS THAT INJURE LOGS AND PULPWOOD. Studies of insects on logs and pulpwood have been continued on a small scale and the results will soon be summarized in a publication. Further development of this project will call for the cooperation of mill operators to test the conclusions drawn from small experimental log piles on a commercial scale, and it is hoped that a cooperative project can soon be instituted. If the same results that have been obtained on a small scale can be duplicated on a commercial scale great savings will be accomplished. Until they have been tested in this way, however, general recommendations cannot safely be made.

6. Methods of Cutting in Jack Pine.

The problem of encouraging the establishment of young growth of red and white pine and spruce by means of proper cutting methods in the extensive stands of merchantable jack pine on the Minnesota and Superior National Forests and elsewhere in the region is an important one. A preliminary study on the Minnesota Forest indicated that partial cutting, by which a considerable portion of the jack pine is left helps to obtain reproduction of red and white pine. In order to check up this preliminary conclusion, two series of permanent sample plots were laid out, one on the Minnesota, and one on the Superior Forest.

On the Minnesota, four 1-acre plots were established in a 50-year stand of jack pine, running about 11,000 board feet to the acre. Large seed trees of red pine were present near each plot and a fair representation of red pine seedlings were already established. One plot was left uncut, a second will have about one-quarter of the stand removed, a third 50 per cent removed, and a fourth almost all of the merchantable material amounting to 85 per cent of the stand. On the Superior, four half-acre plots were established in a 60-year stand of dense jack pine where some seedlings of balsam fir and spruce were already established, and where seed trees of black spruce were present in nearby swamps. One plot was left uncut, one had most of the smaller trees removed leaving the best of the larger ones for

growth, a third had the largest and the poorer smaller trees removed leaving the best of the medium-sized trees for growth, and a fourth was cut to a 6-inch diameter limit. These plots were cut over in November under the supervision of local forest officers, and it is expected that the Minnesota plots will be cut over in a timber sale this winter. The results of these cuttings will become evident only after the effects of the cutting have been observed and recorded for several years.

7. Possibilities of "Scrub" Oak Lands.

The first season's field work on the study of the so-called "scrub" oak lands in northern Michigan has led to several conclusions even before the field data have been completely analyzed. First of all, there is no good reason for calling the oaks on these lands "scrub." Without exception, the small and scrubby-looking oak growth is simply young growth of good species which may be expected to mature and produce merchantable timber products. Five kinds of oak are commonly represented in this type, namely, jack, white, red, scarlet, and black oaks. They occur in varying proportions on the dry sandy soils, mostly rolling or hilly, on many of the sites which were originally occupied by red pine or red and white pine in mixture. The oak seems to be unable to establish itself on the flat sandy outwash plains where jack pine takes possession.

Important areas of the oak type were found in Oscoda, Crawford, Roscommon, Ogemaw, Grand Taverse, Manistee, Lake, Newaygo, and Muskegon Counties. It is estimated that the area of oak lands in the southern peninsula, north of a line between Muskegon and Bay City, must be something over 1,000,000 acres.

Fires are largely responsible for the large areas and the present condition of the oak stands. Originally, the oaks occurred as subordinate species in mixture with the old growth red and white pine. Logging or repeated fires, or both, have removed or destroyed the pines both large and small, and the oaks alone have been able to survive, owing to their capacity to sprout repeatedly after being killed by fire. The large areas of small scrubby growth and of open irregular spacing of the trees is due to the recent and repeated fires. The lack of pines or other conifers in mixture with or coming up under the oaks is similarly due to the fires. In only one or two localities where the lands had been protected were there small areas which had representations of red and white pine with the oak.

Fires are also responsible for most of the rot which is characteristic of the present stands of oak. Most of the trees have been scarred near their bases by fires and the rot has worked in around these scars as they calloused over. Fortunately, the rot does not spread rapidly and is usually confined to the 2 or 3 feet where the trees are scarred at the bases. It is, therefore, not as serious a factor as had been expected, and the evidence from stands which have escaped fire indicates that the oaks will be sound if they are protected from fire.

Fires have done their work so well that there is little prospect of early natural conversion of the oak stands to pine. It will probably be necessary in most places to plant the pines to accomplish the purpose. Plantations of white pine have been established successfully on several of the Michigan State Forests, and red pine can also be used where the oak is not too thick and the pines can be planted in the openings.

Michigan State College cooperated in the project and provided two student assistants who took part in the field work and made the preliminary compilations of

the data in the office. Seventy-seven different small areas were studied intensively and 142 stem analyses of individual trees were made during the field season.

8. Leaf Litter Experiments.

A ton of needles falls to the ground each year in red and jack pine forests, according to the leaf litter studies made by the Station. The amount varies somewhat for different kinds of stands and for different-aged stands, ranging from 1,847 pounds for virgin red and white pine to 2,375 pounds for young jack pine, but the amount hovers close to a ton to the acre each year.

These needles contain many substances essential for plant growth, and the study was made to find out just what amounts of the different materials are given back to the soil each year by the forest.

To collect the leaf fall, burlap strips were laid on the ground in five different localities in red pine and jack pine stands of different ages and densities. Part of the litter was collected in the fall of 1925 and analyzed by the Division of Soils at the University Farm, St. Paul. The final collection was made in the spring of 1926, just one year after the plots were established. The figures given here show the amount of litter that fell during the year on one acre at each plot.

Amount of Leaf Litter Falling on 1 Acre for 1 Year

Plot Number	Location	Kind of Stand	Age Yrs.	Amount of Litter Oven dry weight Pounds
1	Cloquet	75% jack pine 25% red pine Density 75%	50	2,104
2	Cloquet	100% red pine Density 90%	100	2,192
3	Cloquet	100% open grown jack pine Density 75%	30	2,375
4	Cass Lake	75% red pine 25% white pine Density 95%	200 to 250	1,847
5	Cass Lake	100% jack pine Density 90%	55	2,373

The analysis by the Division of Soils at the University Farm of the needles collected in the fall of 1925 gives the following composition of the litter for plots 1 and 2.

Composition of Leaf Litter

Substances	Per cent of dry weight		Pounds per acre for 1 year	
	Plot 1	Plot 2	Plot 1	Plot 2
Ash	2.51	2.01	52.8	44.2
N	.70	.42	14.7	9.2
CaO	.74	.35	15.5	7.7
P_2O_5	.13	.11	2.7	2.4
K_2O	.12	.15	2.5	3.3
$S\ O_3$	.24	.23	5.1	5.0

The number of pounds per acre of the different compounds was based on the analysis for only part of the year but increased in amount on the basis of the total leaf fall to show the amount for the entire year.

One of the most valuable constituents of the leaf litter is the nitrogen which becomes available to plants in the form of nitrates if the litter is undisturbed. Forest fires, when they burn the litter, drive off the nitrogen in the form of gas so it is lost to the soil.

The nitrogen could be replaced by about 70 pounds of sodium nitrate fertilizer, but this would cost in the neighborhood of $3.00 per acre. So the litter of leaves which falls each year is worth $3.00 an acre as it keeps the soil fertile. If the litter is lost by burning or raking, the soil is impoverished and the growth of the forest falls off.

The loss from a fire is greater than the value of one year's fall of litter because there is always the accumulation of three or four years on the ground. The actual loss of ground litter alone from a single fire in red and jack pine stands may easily be around $10.00 an acre.

The Division of Soils of the University of Minnesota will analyze the litter from the other plots before spring so not only the amount of litter which falls in different forests but its composition can be compared. If the burlap strips remain serviceable for another year, the litter will be collected again to substantiate the first year's records.

Plans for 1927

No new projects are recommended for 1927.

During the coming year, the Station will devote its energies to the following eight projects, whose scope and importance have already been discussed:

(1) Management of Northern Hardwoods
(2) Management of Swamp Forests
(3) Possibilities of Aspen--Birch Lands
(4) Fire Studies
(5) Possibilities of Scrub Oak Lands
(6) Methods of Cutting in Jack Pine
(7) Leaf Litter Study
(8) Forest Insects

1. Management of Northern Hardwoods

Extensive field work is planned. On the 20 acres cut selectively last fall and from which 35 per cent of the stand was removed, permanent sample plots will be established to study the growth after such a partial cutting. Other plots will also be established in a stand which will not be cut for 20 years. Next fall, one or two additional areas will be cut by different degrees of selective cutting; only 25 per cent of the stand will be removed in one case, and 50 per cent in the other. Complete records of each operation will be kept, including the stand before and after logging, the amount removed, and the cost of logging and the value of the product. In addition, the logs will be followed through the sawmill if possible, and the actual grades of lumber cut from them will be compared to those cut from logs from a clear cutting operation. Weather records will be continued in the virgin forest and in the open, and in addition observations will be taken in the area cut over last fall to determine the effect of the partial cutting on the forest conditions. The study of Comparative Costs of Logging Small and Large Trees is completed, except for the preparation of the final report. This will be done during the winter.

2. Management of Swamp Forests

Further field work will be necessary. Permanent sample plots will be established in each of the drained swamps at varying distances from the ditches to study the effect of the water level upon forest growth. The water level records will be continued throughout the season on all three swamps, and at the branch station soil and air temperature will also be kept. Samples of peat in each of the swamps will be analyzed to determine its character and chemical composition. The records of the swamp at the Grand Rapids Agricultural Station, which was drained in 1910, will be analyzed and worked up in connection with the increased growth of the forest.

3. Possibilities of Aspen--Birch Lands

No further field work is necessary this year. Last summer four permanent sample plots were established on the Minnesota National Forest to try out three different degrees of cutting and seed spot sowing with white pine and white spruce, with and without the removal of the litter, and with and without rodent screens. These plots will be periodically examined, and at least one additional series of plots should be established. Probably a few additional piles of cordwood of aspen

will be needed to enable the preparation of cordwood yield tables. The office work and preparation of a publication are progressing, but will require two or three months for completion. Two publications are contemplated, one covering the region as a whole, and another dealing with conditions as they are found in Minnesota. The latter is to be published by the Minnesota Agricultural Experiment Station, as a cooperative project between the Cloquet and the Lake States Forest Experiment Stations.

4. Fire Studies

The Analysis of Forest Fire Data has now progressed to the point where the report on Minnesota will be completed this winter. In addition, the fire statistics for 1925 and 1926 for Michigan will be analyzed and a report for Michigan will be prepared. On the basis of the Minnesota and Michigan reports, a general report covering the region as a whole will be then prepared.

The study of the Relation of Weather Conditions to the Occurrence and Severity of Forest Fires, which is a phase of the fire studies, will be continued during the year. Intensive studies of fire hazard, as affected by weather conditions, will be made from time to time as opportunity offers to aid in the proper interpretation of current observations. A preliminary report on the work to date and a revision of the working plan for this project are planned.

The study of the rainfall probability will be completed.

5. Possibilities of Scrub Oak Lands

No further field work is planned. The field data will be analyzed, and a report for publication will be prepared.

6. Methods of Cutting in Jack Pine

Further field work is necessary. The four permanent sample plots established on the Superior National Forest last fall should be supplemented by at least two more series of plots, one in an older and less dense stand in which spruce and balsam reproduction are better established, and another in a younger stand where the effect of cutting on the remaining jack pine will presumably be more marked. The permanent plots established on the Minnesota National Forest were cut over under a timber sale this winter.

7. Leaf Litter Study

No further field work is planned. When the final chemical analyses of the leaf litter are received, the results will be written up and made available for publication.

8. Forest Insects.

No new projects are contemplated. The observations will be continued on the existing plots and extended where conditions, as they develop during the field season, may demand.

Publications

Bulletins and Articles Published during 1926

	Tables for Determining Contents of Standing Timber in Minnesota, Michigan, and Wisconsin. Technical Bulletin 39, University of Minnesota Agricultural Experiment Station. Compiled by Cloquet Forest Experiment Station and Lake States Forest Experiment Station.
Raphael Zon	Effect of Drainage of Swamps upon Forest Growth. Reclamation and Farm Engineering, February, 1926.
	Swamp Drainage. Paper Trade Journal, November 4, 1926.
	Plans for Upper Peninsula Branch Field Station. Development Bureau News, April, 1926.
	The Paul Bunyan of the Future. Gopher Countryman, March 1926.
	Also other brief articles in the Journal of Forestry, Development Bureau News, American Lumberman, Lumber World Review.
Joseph Kittredge, Jr.	Eyes that See and Ears that Hear. Rocky Mountain District Bulletin, November, 1926. Service Bulletin, January 31, 1927.
	The Farmer and the Forests. Wisconsin Farmer, February 25, 1926.
J. A. Mitchell	Precipitation and Forest Fires in Northern Minnesota. Journal of Forestry, May, 1926.
	Fire Weather Forecasting. Development Bureau News.
A. E. Wackerman	Selective Logging and What It Means to the Mining Industry. Proceedings of the Lake Superior Mining Institute for 1926.

	Selective Logging in the Upper Peninsula. Development Bureau News, December, 1926.
S. R. Gevorkiantz	A New Growth Per Cent Formula. Journal of Forestry ,January, 1927.
S. A. Graham	The Fight on Forest Pests in the Lake States. American Lumberman, May 22, 1926.
	Biology and Control of the White Pine. Cornell University Agricultural Experiment Station Bulletin 449. 1926.
S. A. Graham and C. F. Baumhofer	Tip Moth on Nebraska National Forest. Journal of Agricultural Research. (In Press.)
G. E. Marshall and M. J. Cummings	Slash Disposal in Northern Minnesota. American Lumberman, January 29, 1927. (Suggested, placed, and distributed by the Station.)

Publications Planned for 1927

Bulletins

Raphael Zon	Timber Growing and Logging Practice in the Lake States.
Raphael Zon and R. D. Garver	Selective Logging in the Lake States.
Joseph Kittredge, Jr.	Forest Planting in the Lake States.
	Possibilities of Aspen Lands in the Lake States.
	The "Scrub" Oak Lands of Michigan.
J. A. Mitchell	Forest Fires in Minnesota.
	Forest Fires in Michigan.
	Precipitation Probabilities as a Criterion of Fire Hazard.
A. E. Wackerman	Yield of Jack Pine in the Lake States.

Articles

Raphael Zon	The Problem of Pulpwood Supply in the Lake States.
	Silviculture as a Factor in Maintaining the Fertility of Forest Soils.
Raphael Zon and A. E. Wackerman	Leaf Litter in Pine Stands. Its Accumulation and Value.
	Control of Water Level in Swamps to Improve Soil Conditions and Timber Growth.
Joseph Kittredge, Jr.	Effect of Thinning in 18-Year-Old Red Pine.
	Some New Forest Statistics of Michigan.
	Growth of Plantations in Relation to Soil.
	The Use of Soil Surveys in Forest Classification.
S. A. Graham	Effect of Seasonal Cutting on Insect Infestation in Wood.
	Spruce Budworm in the Lake States.
	Spruce Budworm on Jack Pine.

Allotments and Expenditures

The allotments for the Lake States Experiment Station by calendar years are as follows:

July 1, 1923 to Dec. 31, 1924	$33,289.67
1925	27,207.34
1926	26,337.62

Distribution of Funds by States

How the investigative funds were spent by States, since the establishment of the Station, is given below:

	1923 and 1924		1925		1926	
Michigan	$12,375.38	37.2%	$ 7,435.20	27.3%	$ 9,549.14	36.3%
Minnesota	12,503.10	27.5	12,434.19	45.7	13,034.75	49.5
Wisconsin	8,411.19	25.3	7,347.95	27.0	3,753.73	14.2
	$33,289.67	100%	$27,207.34	100%	$26,337.62	100%

Expenditures for 1926, Including State Cooperating Agencies

	Funds of the Station		Cooperation		Total	
Michigan	$ 9,549.14	36.3%	$4,982.00	52.4%	$14,531.14	40.5%
Minnesota	13,034.75	49.5	4,520.00	47.6	17,554.75	49.0
Wisconsin	3,753.73	14.2	-----	---	3,753.73	10.5
	$26,337.62	100%	$9,502.00	100%	$35,839.62	100%

Advisory Committee to the

Lake States Forest Experiment Station

Michigan

Michigan Department of Conservation.
Herman Lunden .....Michigan Hardwood Manufacturers' Agsn.
Prof. L.J.Young .....University of Michigan
Prof. A.K.Chittenden..Michigan State College
John M. Bush .....Upper Peninsula Development Bureau
A. T. Roberts .....Lake Superior Mining Institute

Minnesota

G. M. Conzet .....Minnesota Forest Service
Dean W. C. Coffey.....Department of Agriculture, University of Minnesota
H. C. Hornby .....Northern Pine Manufacturers' Assn.

Wisconsin

C. L. Harrington .....Wisconsin Conservation Commission
Dean H. L. Russell....College of Agriculture, University of Wisconsin
A. L. Osborn.....Northern Hemlock and Hardwood Manufacturers' Association
D. C. Everest.....Wisconsin Protective Association

Members at Large

E. E. Parsonage .....Association of Wood-Using Industries.
D. C. Everest .....American Paper and Pulp Association.

Pulp and Paper Subcommittee

D. C. Everest, Marathon Paper Mills Co., Rothschild, Wisconsin
C. J. McNair, Northwest Paper Company, Cloquet, Minnesota.
W. Irving Osborne, Cornell Wood Products Co., Chicago, Ill.
H. G. Gearhart, Kimberly-Clark Company, Duluth, Minnesota.
Felix Pagenstecher, Bryant Paper Company, Kalamazoo, Michigan.

Lake States Forest Experiment Station

St. Paul, Minnesota.

(Station established 1923)

Raphael Zon	Director
J. Kittredge, Jr.	Silviculturist
J. A. Mitchell	Silviculturist
R. M. Brown	Assistant Silviculturist
A. E. Wackerman	Junior Forester
S. A. Graham	Forest Entomologist
Mary A. Norton	Senior Clerk
Evelyn J. Peck	Junior Clerk

Temporary Field Assistants during 1925.

A. Koroleff
P. H. Bryan
E. L. Demmon
S. R. Gevorkiantz
C. M. Flanagan
P. J. Brown
W. G. Wilson

Collaborators, 1925.

Dr. Henry Schmitz
T. S. Hansen
S. S. Burton

Collaborating Agencies.

University of Minnesota
University of Michigan
Michigan State College of Agriculture
University of Wisconsin
University of Chicago
Northern Hemlock and Hardwood Manufacturers' Association
Upper Peninsula Development Association
Forest Products Laboratory
Department of Conservation of Michigan
Department of Conservation of Wisconsin
State Conservation Commission of Minnesota

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